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The Effects of Tylenol on Non-Social Emotional Memory

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The Effects of Tylenol on Non-Social Emotional Memory

A Thesis

Presented to the Department of Psychology

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Of

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In Fulfillment

Of the Requirements for University Honors

Renato Puga

INTRODUCTION

Flashbulb Memory and Emotion

Brown and Kulik (1977), upon discovering individuals' tendency to have elaborate and detailed memory narratives for discovering shocking public events, coined the term "flashbulb memory." In this regard, it has been consistently found that participants' affect, recounts, and perceived consequentiality of a given event predict more extensive flashbulb memory narratives (Brown & Kulik, 1977; Christianson, 1992). Remarkably, most studies recording the flashbulb phenomenon have consistently paired it with the existence of arousal at the time of discovery. Edery-Halpern and Nachson (2004) assessed Israelis' memories for five different terrorist attacks, and discovered that more elaborate narratives were strongly associated with higher initial affect, higher reported overt recounts, and increased consequentiality, measured by the distance of the attack from one's residence. Similarly, Bohannon and Symons (1992) conducted a study aiming to pinpoint the factors predicting more consistent memories. The results suggested that flashbulb memory consistency for the 1986 Challenger tragedy over a span of 36 months was directly linked with a stronger emotional response to the news as well as with more confidence and more extensive memories.

By influencing to what extent and how often participants recount their memory for discovering a flashbulb event, emotional arousal has also been known to affect memory indirectly (Er, 2003). Hornstein et al. (2003) found a deep-rooted connection between emotional arousal at the time of discovery, as well as recounts, and consistency even after an 18-month delay. Other studies have linked the presence of high initial affect with consistency rates for intervals as long as 3 years (Schmolck et al., 2000). Despite the

connection to other factors such as recounts, confidence, or consequentiality, however, others claim that initial affect is the only primary and main predictor of more elaborate flashbulb memories (Pillemer, 1984).

Although many agree that the flashbulb memory phenomenon occurs, there has been a vast array of theories attempting to explain why, how and if the flashbulb memory mechanism is any different from that involved in the formation of other memories (Bohannon, Gratz, & Cross, 2007). One of the most prominent attempts to unearth the flashbulb memory mechanism has been referred to as the "arousal hypothesis" (Bohannon, 1988; Christianson, 1992). The theory predicts that those who have emotionally strong reactions to shocking news should have a memory advantage for the information cognitively processed 3-5 minutes after the initial discovery (Gold, 1987). According to Bohannon (1988), strong emotions can occur because the news itself is personally and inherently shocking to the hearer or because the news visibly upsets the narrator and those surrounding the hearer. As a consequence of such arousal, concurrently active information is stored in association with the "shocking fact," or, in this context, the flashbulb-eliciting event.

Bohannon, Gratz, and Cross (2007) predicted that individuals learning about an event through different sources (e.g. via another person vs. media) may remember different qualitative aspects of the event. For instance, participants discovering the news of a shocking event through another person usually hear the elemental circumstances surrounding the event (e.g. shuttle exploded), and consequently remember the typical, self-related flashbulb features relating to their personal discoveries. On the other hand, those who learn of shocking events thorough the media are quickly bombarded with the

facts about the event itself (e.g. "At 11:58 this morning the shuttle, Challenger carrying five men and two women, exploded 70 seconds after lift-off from Cape Kennedy") (Bohannon, Gratz, & Cross, 2007). This being the case, they argued that individuals discovering a shocking event through another person are more likely to be more attentive to personal circumstances at the time of discovery, whereas "media" participants are more likely to be exposed to event facts contiguous to their arousal.

Bohannon, Gratz, & Cross (2007) included 2,405 participants in their study at delays ranging from 2 weeks to 50 years, assessing flashbulb memories for their discoveries of multiple publicly shocking events. By statistically controlling a variety of other factors (e.g. recounts, exposures, etc.), the results indicated that, as predicted by the arousal hypothesis, participants receiving the upsetting news from a person tended to remember the personal circumstances of their discoveries better than those receiving the news from the media. Conversely, those receiving the news from the media remembered the details of the event itself better than those who received the news from another individual.

Aside from the supporters of the flashbulb memory mechanism, there are also those who are more skeptical. More specifically, targeting and pinpointing as a considerable weakness the ecological nature of most flashbulb memory research, a number of studies have failed to replicate some of the results setting flashbulb memories as a "special kind" of memory, subsequently concealing them as myths (McCloskey et al., 1988; Talarico & Rubin, 2003). However, a major weakness in these studies has been the small participant samples (generally less than 50) employed in order to derive such conclusions. Thus, despite the truth that the study of ecological phenomena, as is the

study of memories for personal and public events, is helplessly characterized with "noise," most of the practical and theoretical concerns stemming as a result can be ameliorated through the employment of large participant samples (Bohannon & Symmons, 1992).

Constructing Arousal: Unitary vs. Multidimensional Views

With the vast range of research indicating the enhancing effects of emotion on memory, an important question to consider is whether the source of arousal matters. Yerkes and Dodson (1908) postulated that the effects of emotion on memory resembled an inverted-U, assuming that arousal is a unitary process with generalizable properties. Along a similar line, Duffy (1962) characterized arousal as the "excitation of the whole" (pg. 3). Other researchers have also constructed arousal as the nonspecific energetic or intensity component of motivation (Humphreys & Revelle, 1984; Revelle & Loftus, 1992).

An alternative view constructs arousal more along the lines of a multistate or multidimensional process (Neiss, 1988). Lacey (1967) adhered to a similar construction by subdividing the mechanism through which arousal has its effects into three main parts: (1) the physiological, (2) the cognitive, and (3) the behavioral. To further investigate whether the source of arousal does in fact matter, especially in regards to memory enhancement, Libkuman et al. (1999) conducted an experiment in which two sources of arousal were manipulated. More specifically, they induced either physiological (by stationary running or biking) or emotional (by showing slides portraying a surgical procedure) arousal in participants in the study. The factorial designed employed (e.g.

presence or absence of physiological arousal factorially combined with presence or absence of emotional arousal) enabled the possibility to look at the interactive nature of different sources of arousal—that is, if arousal really is a multidimensional process. Furthermore, the measures assessed memory accuracy for information regarding central detail, background detail, and gist. The results indicated that physiological arousal had no enhancing effect on any of the memory measures. Actually, memory for gist, central, and background details was adversely affected by physiological arousal brought through exercise. On the other hand, emotional arousal led to memory enhancement for both background and central details in measures of both recognition and free recall. Hence, these findings support the multidimensional construction of memory as opposed to the unitary view.

Specific action tendencies have been used as an alternative method employed in the investigation of constructing arousal(Frijida, 1986; Lazarus, 1991; Levenson, 1994). In this line of research, emotions have been operationally defined as short-lived experiences leading to coordinated changes in individuals' thoughts, actions, and physiological responses (Fredickson & Branigan, 2005). Adhering to this line of reasoning, during emotional events, specific action tendencies infuse both mind and body, simultaneously narrowing individuals' action urges (e.g. flight in fear, attack in anger) while activating and mobilizing appropriate bodily functions for those particular urges (e.g., increased blood flow to large muscles in fear) (Fredickson & Branigan, 2005). However, especially if different types of arousal lead to different cognitive and behavioral outcomes, it is possible that positive and negative emotions lead to different thought-action repertoires. Fredrickson (1998, 2001) stipulated that, whereas many

negative emotions narrow individuals' momentary thought-action repertoires by eliciting particular behavioral predispositions (e.g. attack, flee), many positive emotions may *broaden* individuals' momentary thought-action repertoires, hence resulting in a pursuit encompassing a wider range of thoughts and actions than is typical (e.g. play, explore, savour, and integrate).

Fredrickson (1998, 2001) goes on to argue that, whereas narrowed thought-action repertoires stemming from negative emotions were likely adaptive to our ancestors within specific threatening instances, the broadened thought-action repertoires of positive emotions were likely adaptive over the long run. Thus, broadened thought-action repertoires gain significance given their utility in building a vast array of personal resources such as physical resources (e.g., physical skills, health), social resources (e.g. friendships, social support networks), intellectual resources (e.g. knowledge, theory of mind, intellectual complexity, executive control), and psychological resources (e.g. reliance, optimism, creativity). Fredickson and Branigan (2005) equated the former argument regarding different thought-action repertoires associated with positive and negative emotions into what they refer to as the *broaden* and *narrow* hypotheses. In regards to the former, positive emotions are predicted to broaden the scopes of attention, cognition, and action, widening the array of thoughts and actions currently in mind. In regards to the latter, negative emotions are thought to narrow these same arrays. Employing a methodological manipulation in which participants viewed a film which elicited either amusement, contentment, neutrality, anger, or anxiety, Fredickson and Branigan (2005) tested this hypotheses. As predicted, compared to a neutral state, positive emotions resulted in broadening in the scope of attention and thought-action

repertoires. Conversely, also in comparison to a neutral state, negative emotions resulted in narrowed thought-action repertoires. Taken together, Libkuman et al. (1999), as well as Fredickson and Branigan (2005), provide strong support for a multidimensional view of arousal as opposed to a unitary construction.

Nature of Emotion's Enhancing Effects on Memory

Having pointed out that arousal may be more appropriately construed as a multidimensional process as opposed to a unitary entity, the apparent enhancing effects in regards to memory open a serious array of questions. For instance, when emotion appears to enhance memory how specifically do arousing stimuli influence neutral stimuli around them? That is, is it only the arousing stimuli that are better remembered or can memory for neutral stimuli associated with the arousal also be enhanced? Furthermore, what impact, if at all, does emotion have on memory for central and peripheral details?

Some research has pointed towards results suggesting that some aspects of an event are better remembered because of its emotional salience, whereas other aspects are more likely to be forgotten (Buchanan & Adolphs, 2002; Reisberg & Heur, 2004). More specifically, proposals stemming from these findings posit that negative arousal causes a narrowing of attention, such that details spatially and temporally associated with the emotional item are attended to and later remembered, while information that is peripheral (e.g. not of central relevance) to the item is likely to be forgotten (Eastbrook, 1959). This finding has been referred to by some as a *central-peripheral trade-off.* The weapon focus effect occurs when an eyewitness is able to describe the criminal's weapon in great detail but possesses little if nay memory about the perpetrator or other aspects of the event

(Cutler, Penrod, & Martins, 1987; Kramer, Buckhout, & Eugenio, 1990; Loftus, 1979; Loftus, Loftus, & Messo, 1987; Maass & Kohnken, 1989). Similarly, other lines of research suggest that when stimuli evoke emotional arousal, the emotion involved affects not only memory for the emotional stimuli but also memory for stimuli appearing just before or after the emotional item. Many studies reveal impaired memory for stimuli preceding or following an emotional item in a list of items (Bornstein, Liebel, & Scarberry, 1998; Hurlemann et al., 2005; MacKay et al., 2004).

Almost paradoxically, however, a number of studies have found quite the opposite effect—that is, emotion at encoding appears to broaden memory and therefore also enhance recall for information other than the emotional stimuli, especially neutral information immediately preceding emotional material (Finn & Roediger, 2011; Knight & Mather, 2009; Nielson & Arentsen, 2012). For instance, Anderson, Wais, and Gabrieli (2006) found that simply appearing before an emotionally arousing picture enhanced memory for a neutral picture a week later—rather than impairing memory for it, as would have been expected based on prior studies citing the perceptual narrowing involved during the presence of emotionally arousing stimuli. Mather and Sutherland (2011) have proposed a mechanism to account for the cited contradictory findings. Arousal-biased competition theory (ABC), as they have called it, suggests that emotional arousal modulates the strength of competing mental representations, enhancing memory for high-priority items while inhibiting memory for low-priority items. To test the stipulations of this theory, Sakaki, Fryer, & Mather (2014) investigated whether goal relevance could help determine whether emotional arousal induces retrograde amnesia or enhancement. They used a series of image sequences presented to participants, which included several

objects and one perceptual emotional or non-emotional critical slide. Some participants were instructed to prioritize the object that came right before the critical slide while some were told to focus on another image. It was found that emotional arousal induced by one image facilitated memory for the preceding neutral items when people prioritized that neutral item, but not otherwise. Hence, depending on the focus of current goals, emotionally arousing images instigated either retrograde amnesia or retrograde enhancement for preceding neutral information. It must be noted, however, that in contrast, memory for subsequent (post-critical) information was not enhanced even when participants were told to prioritize it. In this regard, results in the emotional memory literature have failed to find any sort of indication to suggest that arousal has any sort of enhancing effect on post-critical information (Sakaki, Fryer, & Mather, 2014).

Moreover, Puga, Atkinson, & Bohannon (2012) found both a pre-critical enhancing memory effect and a critical enhancing memory effect. They employed a series of slide shows about a tour through a house with embedded pre-critical, critical, and post-critical slides. There was an emotional and a non-emotional version of the presentation both of which were identical, with the exception that during the emotional condition in the critical slide, a man is portrayed gruesomely chopping some of his fingers off as he cuts a loaf bread. Moreover, the three slides of interest (pre-, critical, and post-) featured arrays of items some of which were perceptually peripheral and some of which were perceptually central. Interestingly, under the emotional condition, the pre-critical slide (that is, the slide that immediately preceded the emotional critical slide) was the best-remembered overall. Peculiarly, in comparison to the non-emotional participants, those in the emotional condition remembered significantly more peripheral items in the

pre-critical slide. In regards to the critical slide, participants in the emotional condition remembered significantly more items from this slide in comparison to the non-emotional participants. However, in line with the literature regarding perceptual narrowing during emotional events, emotional participants appeared to primarily focus and consequently remember more central items at the expense of peripheral items. In short, participants in the emotional condition exhibited a "preceding information effect" in that they showed an enhanced memory effect for pre-critically peripheral items as well as a slightly less robust "critical information effect" in which recall for central items was also enhanced.

The surprising aspect in Puga, Atkinson, and Bohannon (2012) is the fact that the preceding slide in the emotional condition was the best remembered. However, from the stance of evolutionary perspective, this result is not surprising. Arguably, it is of greater evolutionary advantage to more clearly and extensively remember what "predicted the tiger" as opposed to the tiger attack itself. In this way, remembering the events and conditions prior to the tiger attack so that a similar attack may be avoided in the future would serve greater evolutionary utility. Hence, the development of an evolutionary memory mechanism that improves memory not only for threating situations, but also for what *predicts* them, yields significant survival value for the individual and for the species as whole. Knight and Mather (2009) appear to concur with such a view considering their stipulation that emotion-induced enhancement is most likely to occur for neutral items that precede (and are poised to predict the onset of) emotionally arousing items.

Social Rejection, Overlap in Neural Systems, and Acetaminophen

Pajkos et al. (2011) showed that details about harsh social rejections are recalled better than those of polite social rejections. This finding suggests that *social-related emotion* has the potential to also elicit enhancing memory effects akin those of negatively emotional arousal (e.g. seeing a man chopping off his fingers). Furthermore, as MacDonald and Leary (2005) pointed out, English and non-English speakers alike use physical pain words to describe experiences of social distress when complaining of "broken hearts" or "hurt feelings," implicitly indicating the phenomenological similarity between physical pain and social distress, linguistically. Aside from pure linguistic similarities, however, recent evidence points towards a potential overlap in the neural systems underlying the distressing experience that accompanies physical pain and social rejection (Eisenberger et al., 2003). More specifically, recent neuroimaging work has revealed that the dorsal anterior cingulate cortex (dACC), commonly linked to the "unpleasantness" of physical pain (Rainville et al., 1997), is also activated during the distressing experience of social rejection, and its activity correlates considerably with self-reported social distress (Eisenberger et al., 2003).

Taking the results of Eisenberger et al. (2003) a step further, DeWall (2011) asked 62 undergraduates to take 1,000 milligrams of acetaminophen for three weeks. Each evening, these students kept track of the extent to which they experienced social pain that day. Whereas there were no significant changes with participants who took a placebo, the hurt feelings of those who took acetaminophen decreased significantly over time. Functional MRIs also showed that people who had taken acetaminophen also exhibited decreased activity in the brain regions that normally respond to emotional pain. DeWall

(2011) theorizes that even though we may experience social pain differently from physical pain, there seem to exist many commonalities. He suggests that it is feasible that, over the course of human evolution, as we came to depend more on social inclusion for survival, the body's physical-pain system became the system designed to ensure were not secluding ourselves in a hostile world.

Considering the findings suggesting the overlap in neural systems between social and physical pain, as well as acetaminophen's apparent potential in alleviating social pain, Hamamouche, Jennings, & Bohannon (2012) predicted that giving participants a dosage of acetaminophen prior to exposure to a social rejection paradigm may reduce the memory enhancing effects of social rejection. However, Hamamouche, Jennings, & Bohannon (2013) found acetaminophen to enhance memory for details in low arousal conditions (that is, under a polite social rejection) but to have no effect under high arousal conditions (that is, under a harsh social rejection). This finding suggests that, if indeed having memory enhancing capabilities, acetaminophen may activate similar memory modulating systems as arousal—that is, when emotion is at work acetaminophen is not and vice versa. In other words, it is rather peculiar that Hamamouche et al. (2012) only found acetaminophen to enhance memory for details under a polite social rejection (e.g. low arousal conditions). If, on the contrary, acetaminophen had also enhanced memory for details under a harsh social rejection, it could be argued that it is using some enhancing mechanism independent of that used by emotion. However, participants taking acetaminophen under a harsh social rejection (in comparison to those receiving a placebo) performed no different. Hence, it is argued that acetaminophen is having no effect in high arousal conditions since the path it would normally use to enhance memory

is already activated by the arousal associated with the harsh social rejection condition. Taking this line of reasoning a step further, acetaminophen seems to enhance memory under polite social rejections given that the "mechanism" it uses (and allegedly shares with emotion) is not activated under this set of circumstances.

Employing a very similar methodological manipulation as Puga, Atkinson, and Bohannon (2012), with the added stipulation that half the participants were given 500 mg of acetaminophen and half given a placebo, Puga, Spelman, and Bohannon (2014) found Tylenol to enhance participants' memory for post-critical information (**Figure 1**). Post-critical information has not previously been linked with any sort of emotional enhancing effect in the literature. Thus, emotion can be eliminated as potential suspect in accounting for this result, further solidifying the notion that acetaminophen may use similar pathways as emotion to enhance memory.

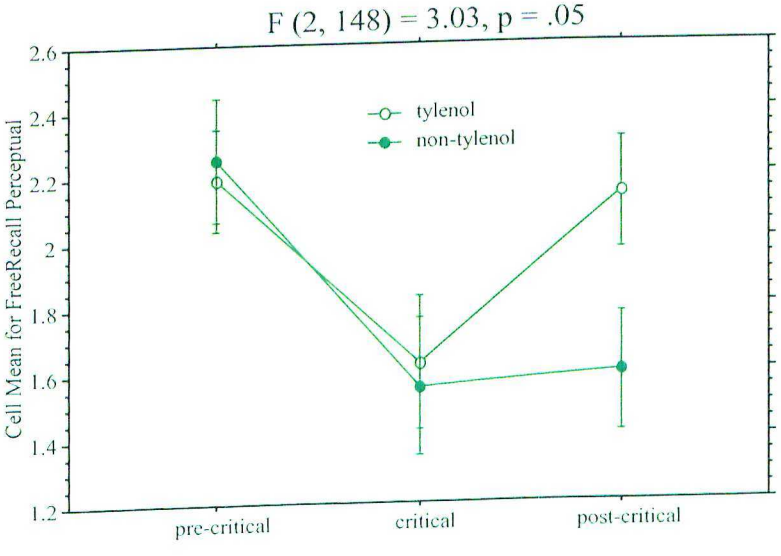

Figure 1.
Slide and Tylenol Interaction

(Puga, Spelman, & Bohannon, 2014)

The present study proposes utilizing a slide-show presentation analogous to the one employed in Puga, Spelman, and Bohannon (2014). However, a new series of pre-critical, critical, and post-critical slides will be utilized, counterbalancing perceptually central/peripheral items across all of them as well as counterbalancing the pre-critical and post-critical slides. The ultimate goal of this manipulation is twofold: To provide a strong methodological scenario in which (1) the "preceding information effect" found in Puga, Atkinson, and Bohannon (2012) as well as (2) the acetaminophen-post critical effect found in Puga, Spelman and Bohannon (2014) can both be re-tested and solidified.

We predict that (1) emotional participants will better recall the pre-critical and critical slides in comparison to the non-emotional participants; and (2) that if Tylenol does indeed have an agonistic memory effect through the activation of similar modulating systems as emotion, then the post-critical slide will be better recalled by the participants receiving the dosage of acetaminophen.

METHOD

Participants

91 participants (68 women, 23 men) were recruited from undergraduate psychology courses to participate in the study during the 2014-2015 school year at Butler University. The students were informed of the nature of the study, including information regarding the duration of participation (roughly 1 hour) and were also warned of the possibility to consume Tylenol in order to participate. Participants were compensated with extra credit towards their psychology classes.

Design

Participants were block-randomized to the different conditions: Emotional/Tylenol, Emotional/Non-Tylenol, Non-Emotional/Tylenol, Non-Emotional/Non-Tylenol. In other words, all participants who showed up at a specific session were assigned to either of these conditions. Hence, the design of the study is a 2 (Tylenol vs. Placebo) x 2 (Emotional Slideshow vs. Non-Emotional Slideshow) x 3 (Slide Order: Pre-Critical, Critical, and Post-Critical). All analyses were performed using a repeated measure ANOVA.

Materials

Acetaminophen was administered to half the participants. The 750 mg dosage was ground using a pill grinder and subsequently mixed in a beverage. Those not receiving acetaminophen were only given the plain beverage. In addition to the acetaminophen given to half the participants, the main manipulation in the study consisted of several emotional and non-emotional slide show presentations. The emotional version of the

presentation included a critical slide portraying a lunch preparation scene in which a man cut off some of his fingers, followed by three more emotionally disturbing images in order to accentuate the emotionality of the presentation. On the other hand, the non-emotional version of the presentation differed only in that during the lunch preparation scene, a man is simply cutting a loaf of bread, followed by three neutral slides of food items. The pre-critical and post-critical slides were the same in all conditions and were counterbalanced between a breakfast and bathroom scene.

It is important to note that in all conditions TBR ("to be remembered") information varied by placement in the slide scene, either centrally or peripherally as well as thematically or athematically. The placement of objects by perceptual centrality (e.g. central or peripheral) was also counterbalanced across the three slides of interest (pre-, critical, and post-) in both conditions, ultimately resulting in four possible slideshow presentations of the emotional condition ([1] Emotional A, Breakfast Pre-Critical, [2] Emotional A, Bathroom Pre-Critical, [3] Emotional B, Breakfast Pre-Critical, and [4] Emotional B, Bathroom Pre-Critical) and four possible presentations for the non-emotional condition ([1] Non-Emotional A, Breakfast Pre-Critical, [2] Non-Emotional A, Bathroom Pre-Critical, [3] Non-Emotional B, Breakfast Pre-Critical, and [4] Non-Emotional B, Bathroom Pre-Critical). For instance, a plate of sunny side up eggs is perceptually peripheral in the pre-critical (Breakfast) slide in Version [1] of the emotional condition, but the same plate of sunny side up eggs is perceptually central in the pre-critical slide in Version [2] of the emotional condition. Moreover, two different word search puzzles were used as distracter tasks, and a mood matrix measuring arousal and

valance was employed in order to assess participants' mood before and after the slide show presentation.

Procedure

Upon arrival, participants were given an informed consent detailing the implications of participation in the study. Immediately after, participants were instructed to report their mood in the mood matrix. Next, they consumed a beverage containing either 750 mg of acetaminophen or an innocuous beverage. After intake, participants engaged in a 30-minute distracter task (word search puzzle [1]) in order for the drug to enter their blood stream. Once the filler task was completed, participants watched a four-minute narrated slideshow presentation about a tour through a house.

Following the presentation, participants once again reported their mood and then completed a 10-minute distracter task (word search puzzle [2]). Lastly, participants were instructed to complete a free-recall activity in which they were asked to remember and write down as many items as possible from the respective pre-critical (breakfast or bathroom), critical (lunch), and post-critical (breakfast or bathroom) slides in the version of the presentation they were shown. Free-recall in the three slides of interest was scored in a right/wrong fashion. Additionally, for those answers that were marked as correct, we also recorded whether those items were perceptually central or peripheral to the scene in which they occurred.

RESULTS

On the arousal ratings, there was only a marginal effect of affect group such that those in the emotional condition (M = .31) reported being slightly more aroused overall than those in the non-emotional condition (M = -.14), F (1, 87) = 2.37, p = .13. However, the time of rating (immediate vs. after the presentation) by affect group (emotional vs. non-emotional) two-way interaction was not significant, F (1, 87) = .39, p = .55. In terms of valance ratings, there were multiple noteworthy effects. First, there was a significant main effect of affect group such that those in the emotional condition (M = .29) reported feeling less pleasant overall than the non-emotional participants (M = 1.5), F (1, 87) = 20.69, p < .0001, d = .47. Second, there was a significant main effect of time of rating such that participants reported feeling more pleasant during the immediate rating (M = 1.60) than they were in the post-presentation rating (M = .20), F (1, 87) = 67.68, p < .0001, d = .86. Most importantly, there was a significant two-way interaction between time of rating and affect group, F (1, 87) = 30.42, p < .0001, d = .57 **(Figure 2).** A post-hoc test revealed that those in the emotional condition reported a significant drop in pleasantness between their immediate (M = 1.47) and post-presentation (M = -.89) ratings, F (1, 44) = 66.1, p < .0001, d = .85. There was no significant difference between pre- and post- ratings for the non-emotional participants.

F (1, 87) = 30.42, p < .0001, d = .57

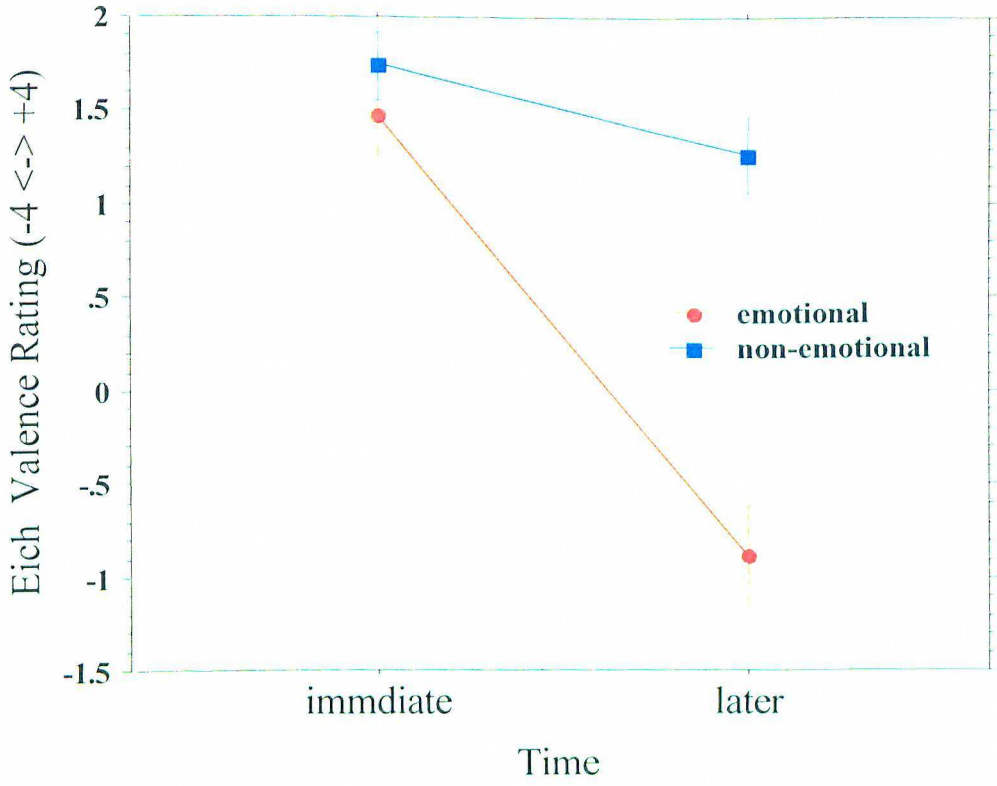

Figure 2.
Valance and Time of Rating

We also analyzed the number of word search puzzle words found by the participants in the different conditions. There was a significant two-way interaction between Tylenol condition and affect group, F (1, 87) = 7.42, p = .008, d = .27 **(Figure 3).** A post-hoc test revealed a significant difference such that, during the emotional condition, non-Tylenol participants (M = 23.83) found more words overall than Tylenol participants (M = 22.31), F (1, 43) = 9.39, p < .004; however, in the non-emotional condition, Tylenol participants (M = 23.33) outperformed their non-Tylenol counterparts (M = 22.04) marginally, F (1, 44) = 2.05, p < .16, d = .11.

F (1, 87) = 7.42, p = .008, d = .27

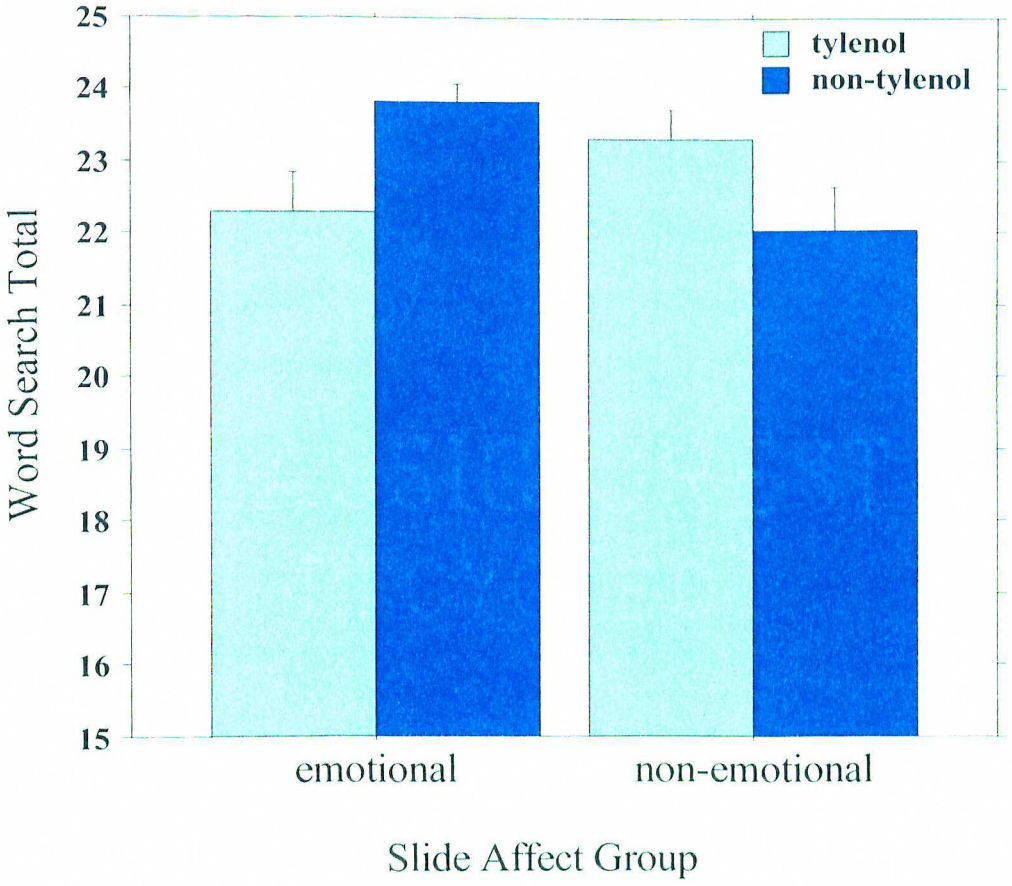

Figure 3.
Crossword Performance: Tylenol Condition and Affect Group

In regards to free-recall, there was a significant main effect of slide, F (2, 138) = 28.74, p < .0001, d = .78. A post hoc test revealed that the pre-critical slide (M = 2.5) was significantly better remembered than the critical slide (M = 1.33), F (1, 89) = 66.06, p < .0001, d = .85.. There was also a significant two-way interaction between slide and affect group, F (2, 138) = 6.61, p = .002, d = .35 (**Figure 4**). A post hoc test showed that the pre-critical slide was significantly better remembered by emotional (M = 2.83) than by

non-emotional (M = 2.27) participants, F (1, 89) = 4.47, p < .04, d = .20; conversely, non-emotional participants (M = 2.28) remembered marginally more items in the post-critical slide than the emotional participants (M = 1.78), F (1, 89) = 1.36, p < .15, d = .06.

There was a significant two-way interaction between slide and Tylenol condition, F (2, 138) = 3.88, p = .02, d = .25 (**Figure 5**). More specifically, a post hoc test revealed that Tylenol participants (M = 2.44) remembered marginally more items in the post-critical slide than non-Tylenol participants (M = 1.86), F (1, 89) = 2.52, p < .12, d = .13. Non-Tylenol participants (M = 2.67), in turn, marginally outperformed Tylenol participants (M = 2.23) in the pre-critical slide, F (1, 89) = 2.5, p < .12, d = .13. Lastly, we found a significant three-way interaction among slide, perceptual centrality, and affect group, F (2, 138) = 4.65, p = .01, d = .28. That is, emotional participants (M = 1.85) remembered marginally more peripheral items in the pre-critical slide in comparison to those in the non-emotional condition (M = 1.26), F (1, 89) = 3.28, p < .07, d =. 16; in the critical slide, emotional participants (M = 2.74) remembered significantly more central items than non-emotional participants (M = 1.85), F (1, 89) = 5.99, p < .02, d = .23.

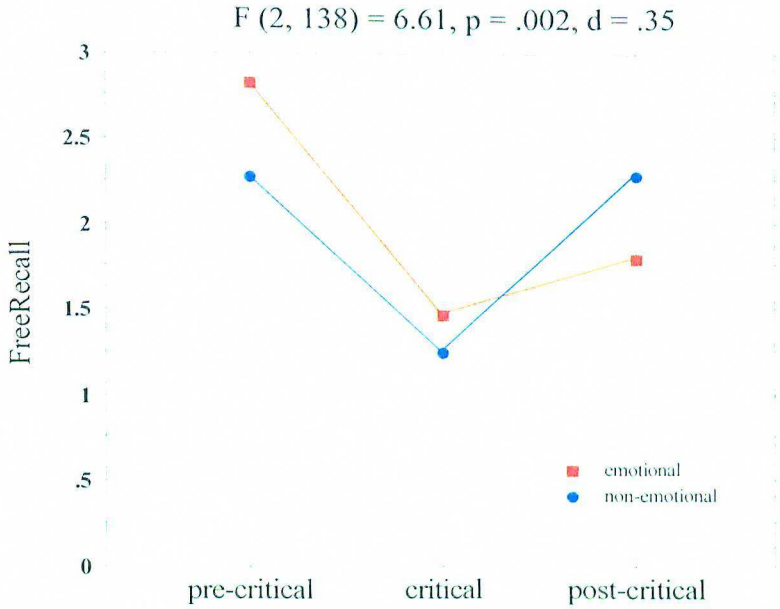

Figure 4.
Slide and Affect Group Interaction

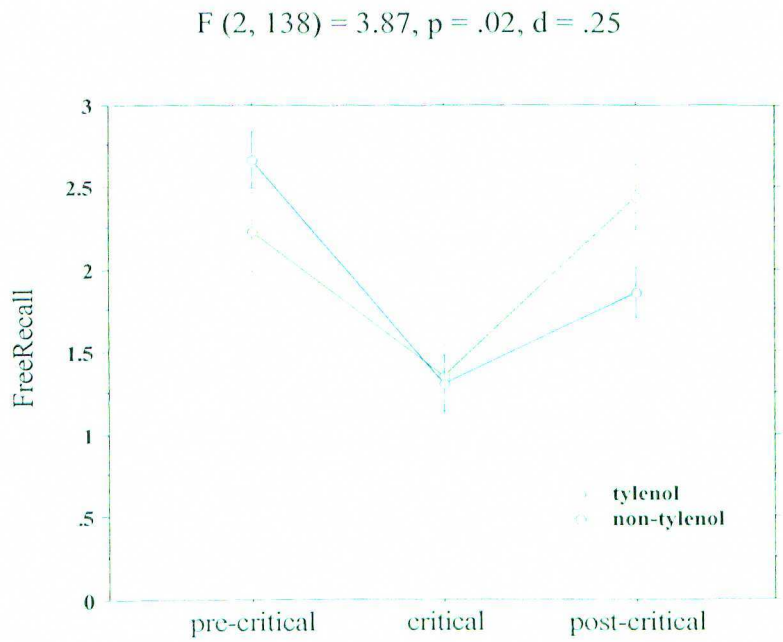

Figure 5.
Slide and Tylenol Condition Interaction

DISCUSSION

It was hypothesized that (1) emotional participants would better recall the pre-critical and critical slides in comparison to the non-emotional participants; and (2) that if Tylenol does indeed have an enhancing memory effect through the activation of similar modulating systems as emotion, then the post-critical slide would be better recalled by the participants receiving the dosage of acetaminophen. Both of the hypotheses were at least partly supported. In regards to the first hypothesis, as can be seen in Figure 4, those in the emotional condition recalled more items in the pre-critical slide than their non-emotional counterparts. However, even though emotional participants also recalled more items in the critical slide in comparison to those in the non-emotional condition, this difference was non-significant. Despite this apparent difficulty, the three-way interaction among slide, perceptual centrality, and affect group supported hypothesis (1), nonetheless. This is due to the fact that, even though emotion may not have enhanced information overall in the critical slide, emotion did enhance memory for the central items in this slide as well as memory for the peripheral items in the pre-critical slide.

This finding is a replication of Puga, Atkinson, and Bohannon (2012). Namely, this is rather remarkable in the sense that, in addition to counterbalancing pre-critical and post-critical slides, the perceptual centrality in all the items in the three slides of interest was also counterbalanced. Hence, with this further counterbalancing procedure, we can eliminate the possibility that the peripheral items in the pre-critical slide or the central items in the critical slide were more likely to be recalled because they may have been easier to remember. That is, the memory effect persisted regardless of which scene constituted the pre-critical slide (bathroom vs. breakfast) or regardless of what items were

perceptually central or peripheral in the pre-critical and critical slides. Ultimately, the current findings support the original results of Puga, Atkinson, and Bohannon (2012), especially considering the more rigorous and controlled methodology employed in the current study.

In regards to hypothesis (2), the present study provides important insight. As predicted, participants in the Tylenol condition exhibited a post-critical memory enhancing effect, thus replicating Puga, Spelman, and Bohannon (2014). Emotion can be ruled out as the culprit responsible for this effect given that in the slide by affect group two-way interaction (Figure 4), emotion did not elicit memory enhancement for the post-critical slide. Moreover, the fact that Tylenol did not enhance memory for the pre-critical or critical slides (that is, when emotion is at work) lends support to the hypothesis that acetaminophen may indeed be using a *similar* neurological pathway as emotion to achieve its memory enhancing effect. In other words, the fact that acetaminophen, for instance, does not further enhance memory for pre-critical items under emotional conditions is noteworthy. If acetaminophen were using a modulating system completely independent of the one used by emotion to enhance memory, it would be reasonable to expect an additive memory enhancing effect on pre-critical items in the emotional condition when Tylenol is also present—that is, enhancement due to emotion *and* enhancement due to acetaminophen. However, when emotionally induced memory enhancement is present (e.g. for pre-critical or critical information under emotional conditions) acetaminophen does not further this enhancing effect. Rather, when the effects of emotion are not present (e.g. post-critical information under emotional conditions) is when the memory effect of acetaminophen appears. It should be noted that

it is fully possible that acetaminophen may be using modulating systems to enhance memory other than the one employed by emotion. However, the main claim of the present argument is to state that there appears to be an overlap in the mechanisms employed by both emotion and acetaminophen to enhance memory. This is not to postulate that acetaminophen achieves its enhancing memory effects in the exact same manner as emotion.

The Tylenol condition by affect group two-way interaction (Figure 3) on the number of words correctly identified during the word search puzzles may shine further light onto the latter supposition. More specifically, the fact that Tylenol had an agonistic effect on the number of words found under non-emotional conditions may indicate Tylenol potentially has a cognitive effect that is broader than just a memory effect. Nonetheless, the pattern of the effect found on the word search puzzles falls in line with the memory effect obtained given that Tylenol once again did not have an effect under emotional conditions.

Overall, this study provides support to the "tiger hypothesis" advanced in Puga, Atkinson, and Bohannon (2012); that is, remembering what predicted the attack of the tiger is of greater evolutionary advantage than remembering the attack itself. Hence, it makes evolutionary sense why individuals under emotional circumstances exhibit intensified memory for pre-critical information, especially for peripheral objects. At the same time, the results of the present study help build the case of an agonistic Tylenol memory effect that may "borrow" modulating pathways employed by emotion to achieve its effect. However, much remains to be done in order to fully pinpoint the nature of this

effect. To accomplish such an endeavor, a multi-disciplinary approach involving, but not limited to, psychology, neuroscience, and pharmacology will be necessary.

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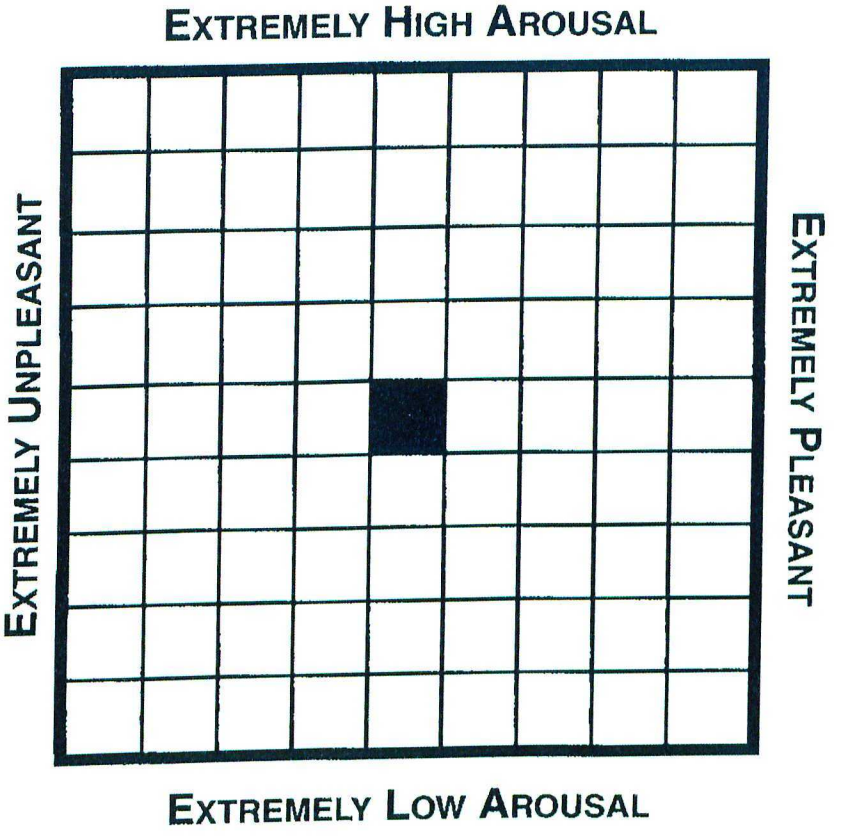
Appendix A
(Mood Matrix)

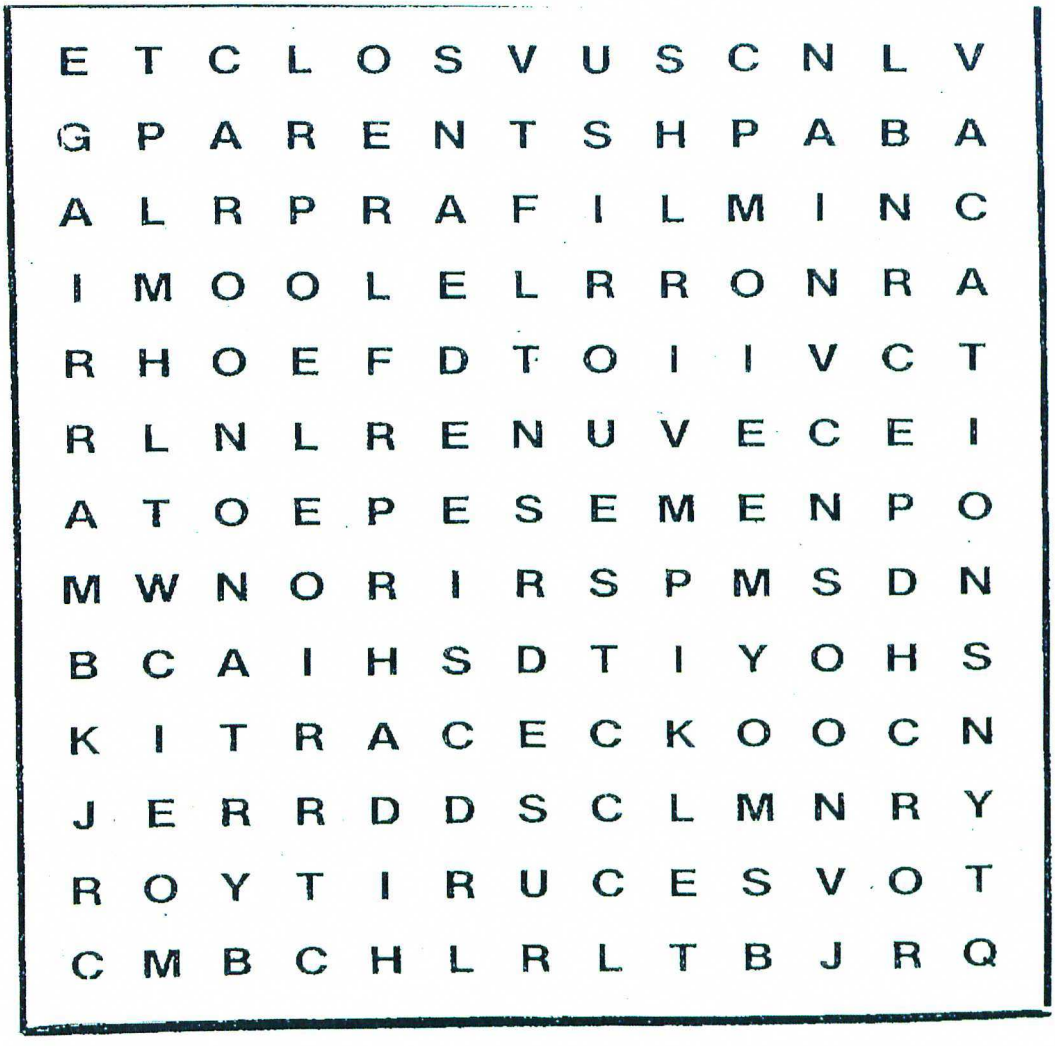
Please fill in the box that best describes your current state of arousal and pleasantness.



Appendix B
(Word Search [1])

ALTER
ARRANGE
ATTUNE
AUGMENT
AVERT
CONTORT
CROOKED
DENY
DETOUR
DIET
EDIT
EVOLVE
FLEE
GROW
INFLUENCE
INNOVATE
MATURE
MODIFY
MODULATE
OVERRULE
REACT
REDUCE
REFORM
REMODEL
REVERSE

Appendix C
(Word Search [2])



E T C L O S V U S C N L V
G P A R E N T S H P A B A
A L R P R A F I L M I N C
I M O O L E L R R O N R A
R H O E F D T O I I V C T
R L N L R E N U V E C E I
A T O E P E S E M E N P O
M W N O R I R S P M S D N
B C A I H S D T I Y O H S
K I T R A C E C K O O C N
J E R R D D S C L M N R Y
R O Y T I R U C E S V O T
C M B C H L R L T B J R Q

ACCEPTED
ANNIVERSARY
AWARD
BIRTH
CHILDREN
COMMUTER
DIPLOMA
FRIENDS
HOME
HOPES
JOB
JOY
LOVE
LUCKY
MARRIAGE
NORMAL
PARENTS
PROFESSION
RETIRE
SCHOOL
SECURITY
TALENT
TRIPS
VACATIONS

Appendix D
(Free Recall Questionnaire)

Please work as an individual to recall as many items from the selected scenes as accurately and as detailed as you can remember. You do not have to provide an answer for every line.

Breakfast Scene

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____

Lunch Preparation Scene

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____

Bathroom Scene

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____

Appendix E
([1] Emotional A, Breakfast Pre-Critical)

BREAKFAST (PRE-CRITICAL)

LUNCH (CRITICAL)

BATHROOM (POST-CRITICAL)

APPENDIX F
([2] Emotional A, Bathroom Pre-Critical)

BATHROOM (PRE-CRITICAL)

LUNCH (CRITICAL)

BREAKFAST (POST-CRITICAL)

APPENDIX G
([3] Emotional B, Breakfast Pre-Critical)

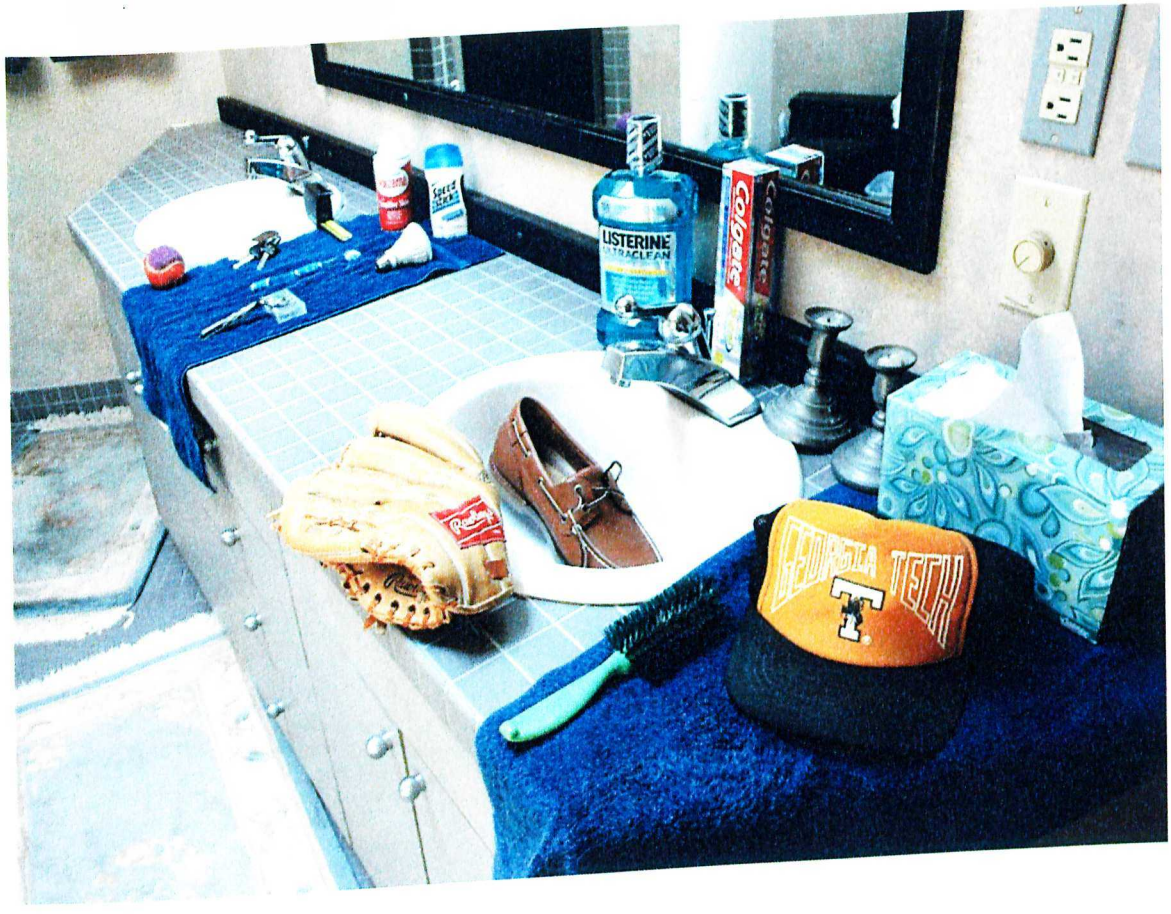
BREAKFAST (PRE-CRITICAL)

LUNCH (CRITICAL)

BATHROOM (POST-CRITICAL)

Appendix H
([4] Emotional B, Bathroom Pre-Critical)

BATHROOM (PRE-CRITICAL)



LUNCH (CRITICAL)

BREAKFAST (POST-CRITICAL)

Appendix I
([1] Non-Emotional A, Breakfast Pre-Critical)

BREAKFAST (PRE-CRITICAL)

LUNCH (CRITICAL)

BATHROOM (POST-CRITICAL)

Appendix J

([2] Non-Emotional A, Bathroom Pre-Critical)

BATHROOM (PRE-CRITICAL)

LUNCH (CRITICAL)

BREAKFAST (POST-CRITICAL)

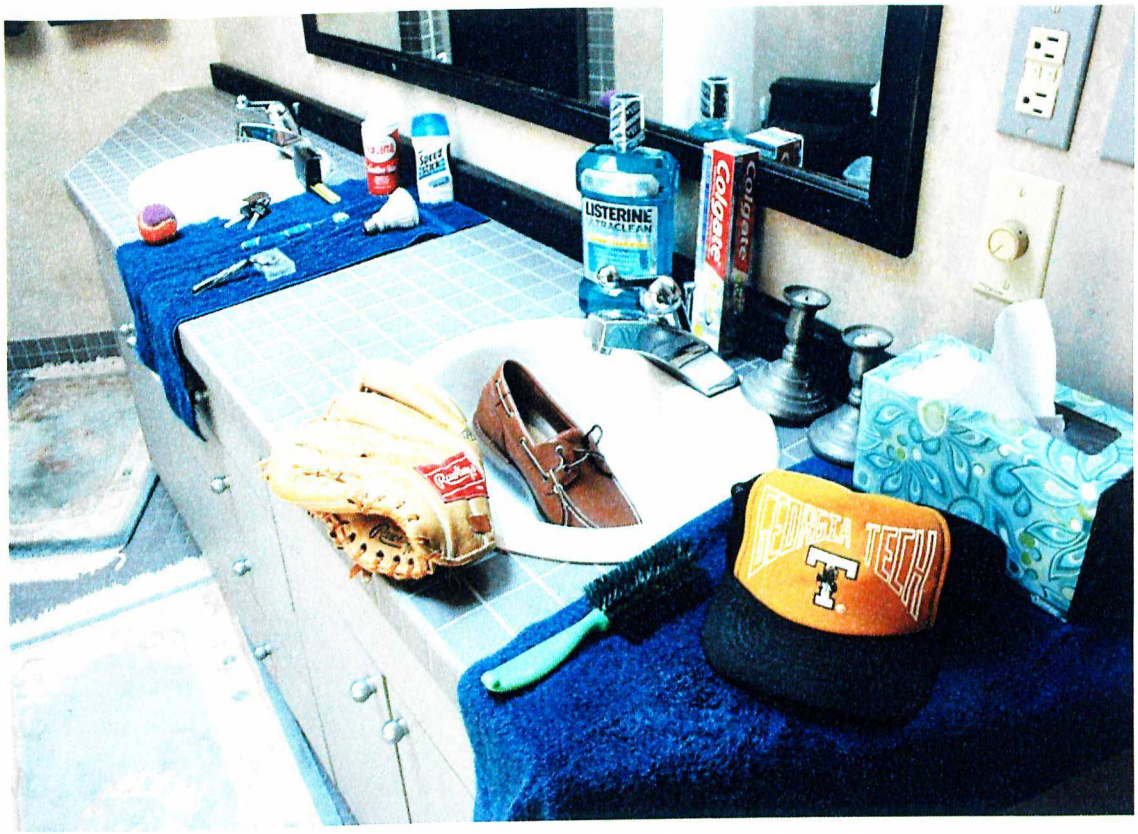
Appendix K

([3] Non-Emotional B, Breakfast Pre-Critical)

BREAKFAST (PRE-CRITICAL)

LUNCH (CRITICAL)

BATHROOM (POST-CRITICAL)



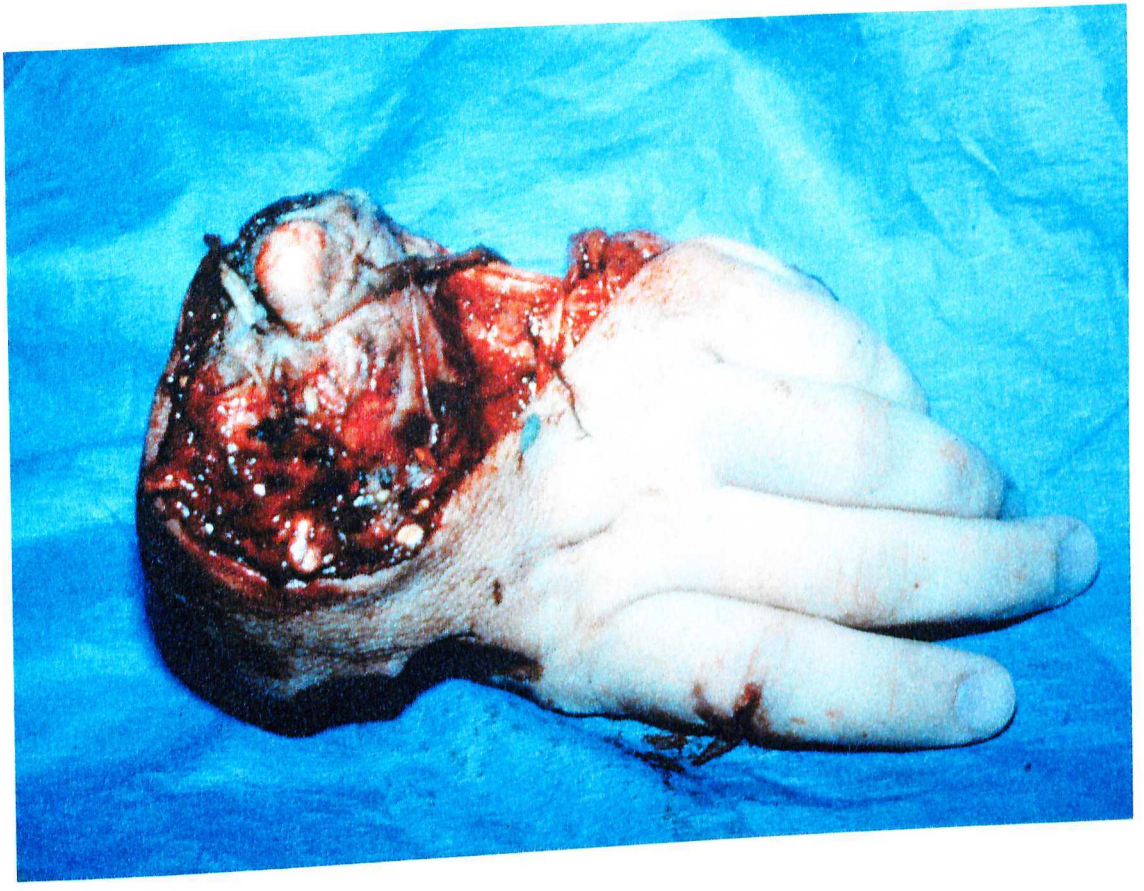
Appendix L
([4] Non-Emotional B, Bathroom Pre-Critical)

BATHROOM (PRE-CRITICAL)

LUNCH (CRITICAL)

BREAKFAST (POST-CRITICAL)

Appendix M
(Series of Slides Following Critical Slide in All Versions of Emotional Presentation)



Appendix N

(Series of Slides Following Critical Slide in all Versions of Non-Emotional Presentation)


Campbell's
1/2 THE FAT


Del Monte
Lite
SNACK SIZE
SLICED PEACHES
Christine Ferguson
VEGETABLE SOUP
10/3/96